Importance of Quality Assurance

FOR EQUIPMENT AND SYSTEMS CRITICAL TO ELECTRICAL SAFETY

This discussion addresses the importance of routine maintenance, i.e. the importance of having a robust process for quality assurance of functionality of equipment and systems critical to electrical safety of personnel. There is a subset of the total electrical installation that is critical to electrical safety. Installation deficiencies and failures of this subset can exist as hidden failures, with no apparent shortcoming in functionality until an event with serious injury potential occurs. Examples of electrical safety critical equipment and systems include the mechanical integrity of covers, doors and barriers that prevent people from contacting hazardous voltage during normal operations; the functional performance of circuit protective devices that protect people from arc flash and blast during fault conditions; and the integrity of grounding and bonding systems that enable operation of overcurrent protective devices, prevent arcing and sparking in the fault return path, and prevent presence of hazardous voltage on cabinets, enclosures, and structures, during normal operations.

Arc Flash Hazard Mitigation

In recent years, the increasing knowledge and understanding of the arc flash hazard has significantly changed the requirements for overcurrent protective devices. The arc flash hazard analysis and the selection of thermal personal protective equipment are completely dependent on the protective devices to function exactly as designed. The equipment and systems that provide overcurrent protection relative to arc flash hazard mitigation are critical to the safety of personnel who interact with the electric power equipment. Circuit breakers must function as new. Overcurrent devices must operate at the designed and documented pick up and time settings. If circuit breakers or protective devices are dependent on an external power supply, the tripping power system (usually batteries and battery charger) must be functioning as designed. If the protective device is a fuse, the installed fuse must meet the design specifications and be the type, class and rating of the one documented in the arc flash analysis. There should be a robust quality assurance process to assure no deviation from this expectation.

Case History #1: Maintenance Erosion

A manufacturer of medical diagnostic instruments applied Prevention through Design concepts to reduce arc flash incident energy in its industrial power distribution systems by retrofitting fast-acting current limiting (Class RK-1) fuses. This class of fuse has the benefit of significantly lowering thermal incident energy during an arc flash event, thus reducing and sometimes eliminating need for arc rated personal protective equipment. Five years after the 100% retrofit, an audit found that 20% of the installed fuses were no longer RK-1 fuses. This meant that in some cases, potential incident energy exposure was an order of magnitude greater than was anticipated, the PPE used for those situations was now underrated, and serious injury could be suffered by workers who thought were properly protected. In this case, communications had broken down between facility management and contracted electrical services on the expectation that only class RK-1 fuses were to be used in the facility. Over time, the 100% class RK-1 fuse redesign had eroded due to misunderstanding and lack of an effective quality assurance process. Fig. 1 illustrates a hidden failure in the Feeder Circuit Breaker that impacts worker protection at the Switch. In this case, a failure impacting functionality of the Feeder Circuit Breaker was not apparent to operations personnel until an arc flash event occurred at the Switch.

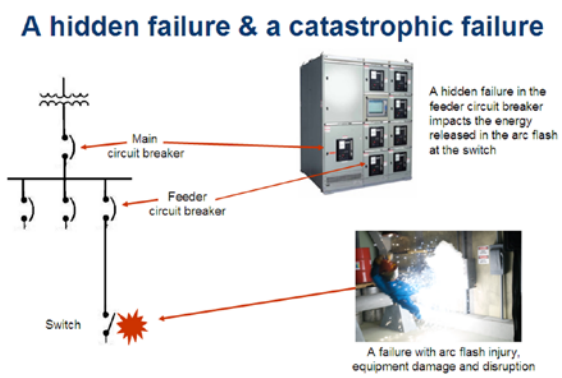

Fig. 1 A hidden failure in the Feeder Circuit Breaker overcurrent protection can result in order of magnitude greater incident energy at the Switch

In this illustration, the Main Circuit Breaker serves as backup protection to the Feeder Circuit Breaker.

Shock Hazard Mitigation

Fundamental to shock protection is bonding & grounding of conductive enclosures, housings and covers of electrical equipment and tools, as well as conductive components of buildings, structures and mobile equipment. The metallic non-current conducting parts of machinery, tools, appliances, buildings and structures can present lethal exposure to electric shock hazards if 1) the metallic part comes in contact with an electrical energy source, and 2) the metallic part is not adequately bonded and grounded. In the U.S., contact with lethal electrical energy during routine interaction with machines and handling of portable tools and appliances is the 3rd leading cause of electrocution fatality in the workplace. All personal have exposure to this electric shock scenario, both on and off the job. Preventing this exposure is the primary purpose of equipment grounding and bonding and the application of ground fault circuit interrupters (GFCIs).

Case History #2: Installation Defect

The administrative office building of an industrial petrochemical plant included a medical services facility. During a spot inspection of the 120V receptacle outlets in the medical facility, it was discovered that the equipment grounding conductor was not connected at each 120V outlet. The grounding conductor was neatly coiled and pushed to the back of each outlet box. Due to misunderstanding of design requirements for the medical equipment that would be plugged into these outlets, the installation contractor had intentionally not connected the equipment grounding conductor. The outlets were functional in the sense that power was delivered to plugged-in equipment. However, there was potential for serious electric shock and possible electrocution if a failure in any of the connected equipment resulted in voltage on equipment case or enclosures.

Fig. 2 Left: Grounding conductors at a main substation.
Center: A conductive cabinet that could become energized if there is a wiring insulation failure and the enclosure is not bonded to the grounding conductor.
Right: A worker using an electrically powered tool depends on bonding and grounding to prevent a potentially fatal electric shock.

In the examples shown in Fig 2, a design, installation or maintenance defect impacting the effectiveness of the bonding and grounding system can produce a hidden failure that will not be apparent until a shock incident occurs.

In Summary

This article is intended to bring attention to the need to have an effective and robust process in place to help assure the quality of engineering controls critical to electrical safety for personnel. The common failure modes for this subset of electrical equipment are typically hidden failures. The quality assurance process should address design, installation, commissioning and maintenance of equipment and systems that serve to mitigate arc flash and shock exposures.

Reference

Cawley, J.C and Brenner, B.C., “Occupational Electrical Injuries in the U.S., 2003-2009”, *IEEE Industry Applications Magazine*, May/June 2013, pp 16-20.